Green Acton &
League of Women Voters
1,4-Dioxane Panel

October 25, 2018

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Outline – Groundwater Protection/Treatment

- How 1,4-dioxane got into OUR drinking water wells
- How to keep it out of our wells? Two steps:
  - Pumping to intercept the contaminated GW before it gets close to our wells.
  - Treat the residual source material that continually "bleeds" in to the GW way upgradient at the NMI site.
- What happens to the water when it gets pumped out of the ground ("extracted" from the ground)?

1,4-Dioxane

[From:https://www.epa.gov/sites/production/files/2014-03/documents/ffrro_factsheet_contaminant_14-]dioxane_january2014_final.pdf]

EPA United States Environmental Protection Agency

Technical Fact Sheet – 1,4-Dioxane
November 2017

TECHNICAL FACT SHEET – 1,4-DIOXANE

At a Glance

- Flammable liquid and a fire hazard. Potentially explosive if exposed to light or air.
- Found at many federal facilities because of its widespread use as a stabilizer in certain chlorinated solvents, paint strippers, greases and waxes.
- Short-lived in the atmosphere, may leach readily from soil to groundwater, migrates rapidly in groundwater and is relatively resistant to biodegradation in

Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a summary of the emerging contaminant 1,4-dioxane, including physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information. This fact sheet is intended for use by site managers who may address 1,4-dioxane at cleanup sites or in drinking water supplies and for those in a position to consider whether 1,4-dioxane should be added to the analytical suite for site investigations.

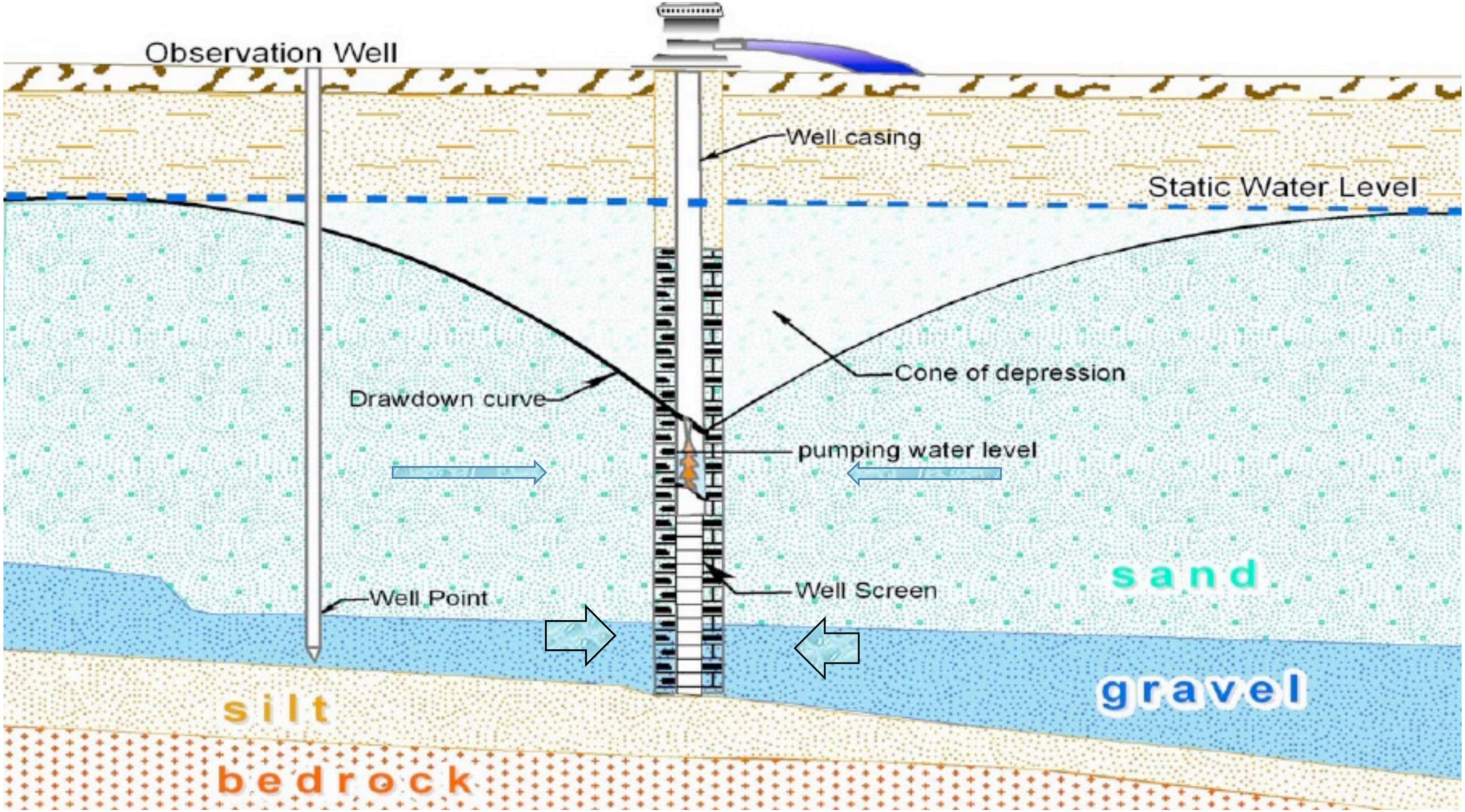
1,4-Dioxane is a likely human carcinogen and has been found in groundwater at sites throughout the United States. The physical and chemical properties and behavior of 1,4-dioxane create challenges for its characterization and treatment. It is highly mobile and does not readily biodegrade in the environment.

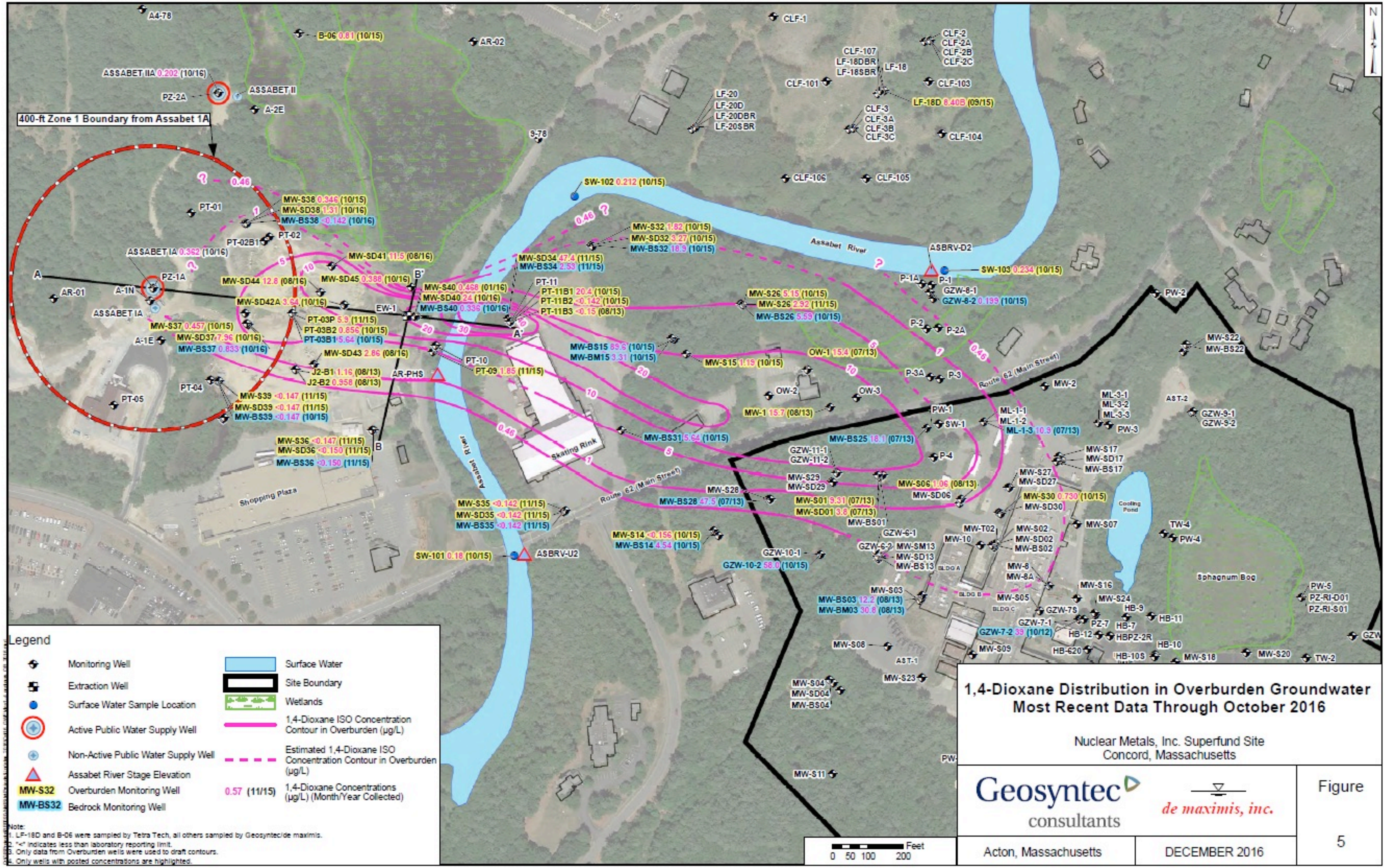
"1,4-Dioxane is a synthetic cyclic ether generally found at sites in association with releases of chlorinated solvents, especially 1,1,1-TCA.

1,4-dioxane is highly miscible in water, mixing with water so readily that it can be found in groundwater plumes far in advance of any solvents with which it was originally released. It also migrates rapidly in soil and can readily leach into groundwater. 1,4-dioxane does not adsorb significantly to suspended sediments and is relatively resistant to biodegradation. Volatilization occurs relatively rapidly from dry soils, but relatively slowly from surface water."

“Idealized” Graphic of a Drinking Water Production Well

Drinking Water Well – (e.g., Assabet 1)





1,4-Dioxane Distribution in Overburden Groundwater Most Recent Data Through October 2016

Nuclear Metals, Inc. Superfund Site
Concord, Massachusetts

Geosyntec consultants | de maximis, inc.

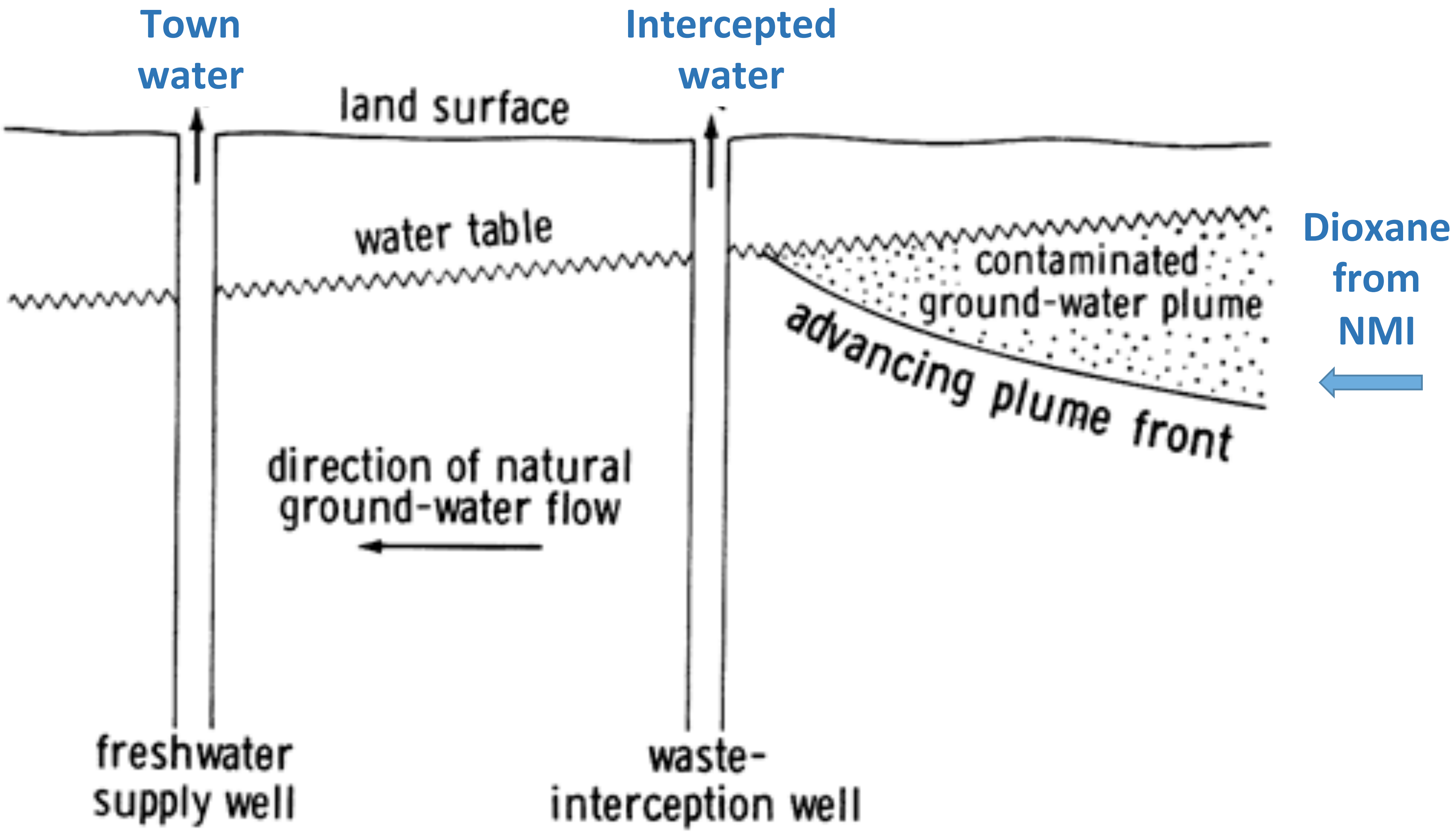
Acton, Massachusetts | DECEMBER 2016

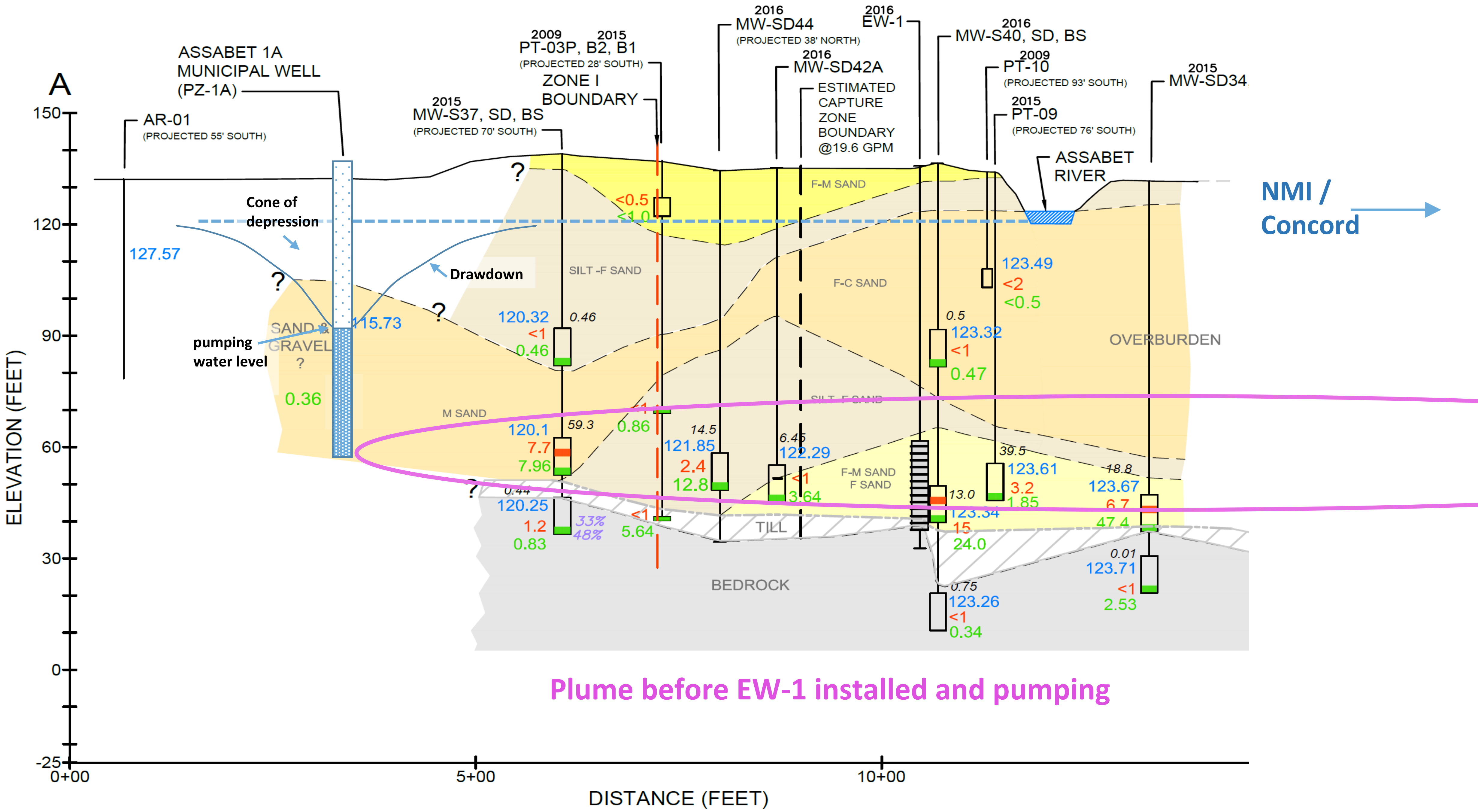
Figure 5

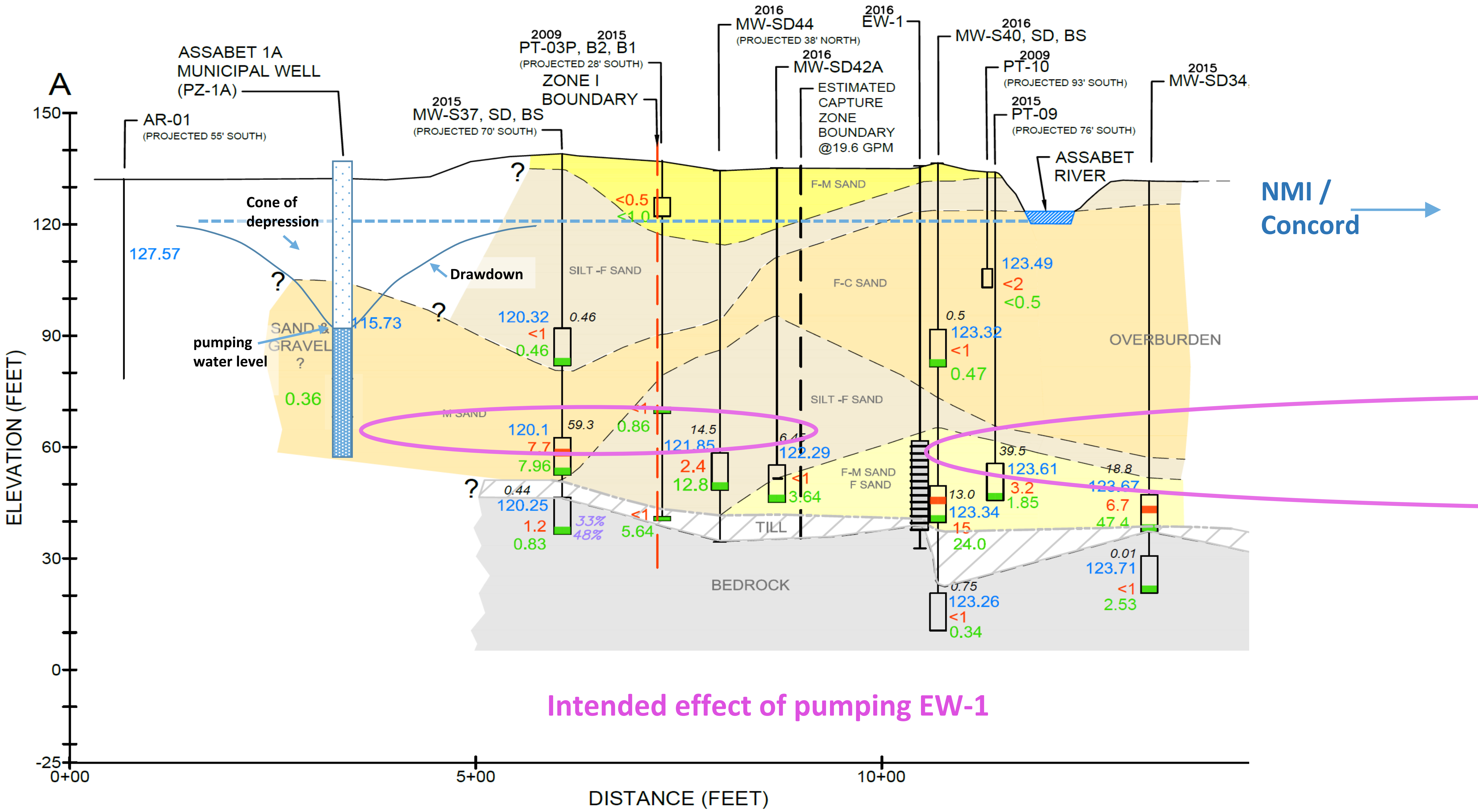
How do we protect Drinking Water Wells?

- There are normally a variety of options; but with 1,4-dioxane contamination there are few
- There are no reliable *in-situ* treatment options (i.e., hard to treat the water while it is in the ground)
- Typical approaches are:
  - intercept the contamination before it reaches the drinking water wells
  - treat the drinking water before enters distribution system
- (Talk about other possibilities in a minute…)

“Cartoon” of plume interception




A
ASSABET 1A MUNICIPAL WELL (PZ-1A)
AR-01 (PROJECTED 55' SOUTH)
2015 MW-S37, SD, BS (PROJECTED 70' SOUTH)
2009 2015 PT-03P, B2, B1 (PROJECTED 28' SOUTH)
ZONE I BOUNDARY
2016 MW-SD44 (PROJECTED 38' NORTH)
2016 MW-SD42A
ESTIMATED CAPTURE ZONE BOUNDARY @19.6 GPM
2016 EW-1
2016 MW-S40, SD, BS
2009 PT-10 (PROJECTED 93' SOUTH)
2015 PT-09 (PROJECTED 76' SOUTH)
ASSABET RIVER
2015 MW-SD34
NMI / Concord
Cone of depression
Drawdown
pumping water level
SAND & GRAVEL
M SAND
SILT -F SAND
F-M SAND
F-C SAND
OVERBURDEN
F-M SAND F SAND
TILL
BEDROCK
ELEVATION (FEET)
DISTANCE (FEET)
0+00
5+00
10+00
Plume before EW-1 installed and pumping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Cone of
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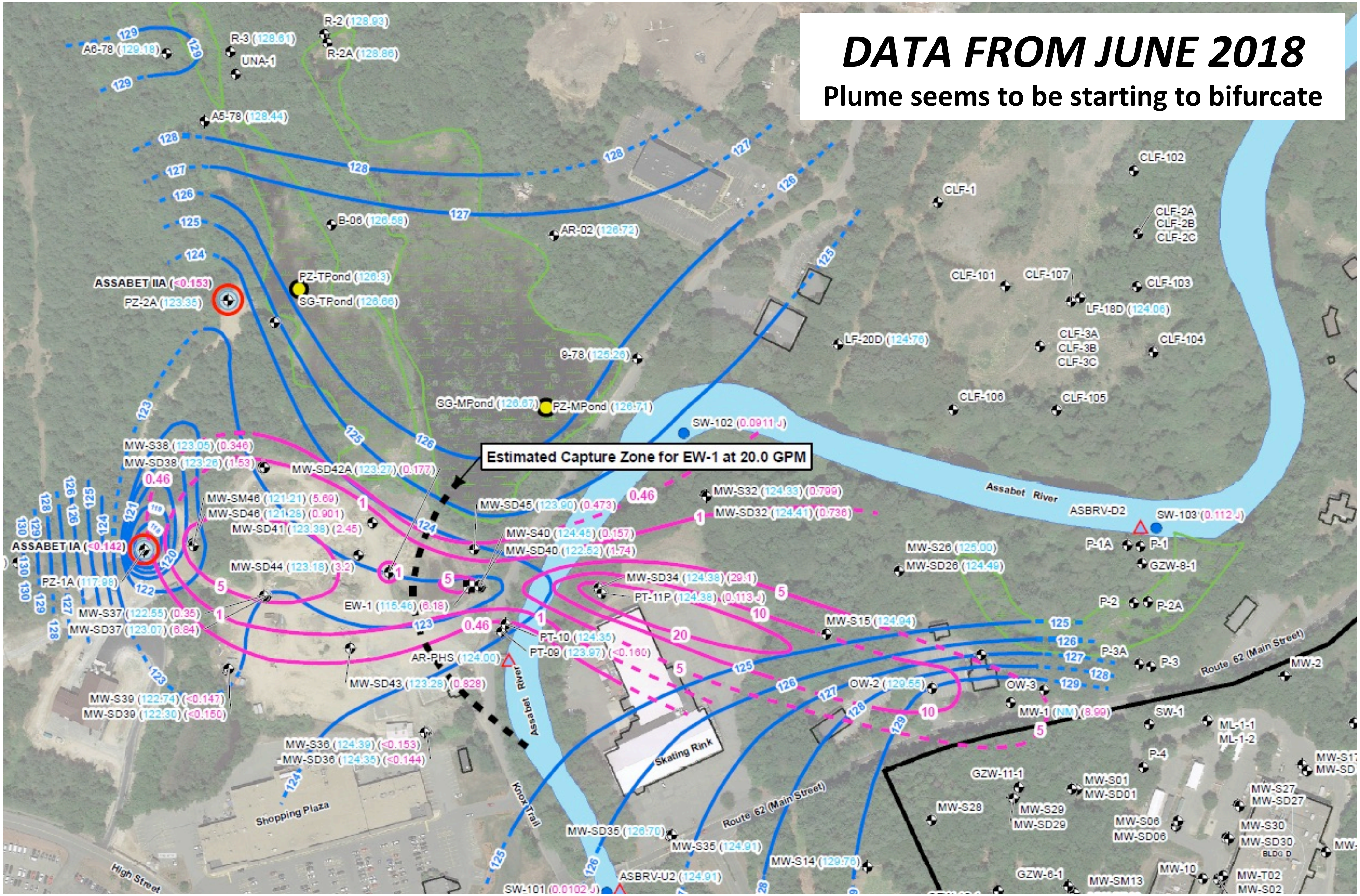
Drawdown
pumping
water level
127.57
115.73
0.36
SAND &
GRAVEL
M SAND
SILT -F SAND
F-M SAND
F-C SAND
SILT -F SAND
F-M SAND
F SAND
TILL
BEDROCK
OVERBURDEN
120.32
<1
0.46
0.46
<0.5
<1.0
120.1
7.7
7.96
59.3
0.86
0.44
120.25
1.2
0.83
33%
48%
<1
5.64
14.5
121.85
2.4
12.8
122.29
<1
3.64
123.49
<2
<0.5
0.5
123.32
<1
0.47
13.0
123.34
15
24.0
0.75
123.26
<1
0.34
39.5
123.61
3.2
1.85
18.8
123.67
6.7
47.4
0.01
123.71
<1
2.53
ELEVATION (FEET)
150
120
90
60
30
0
-25
0+00
5+00
10+00
DISTANCE (FEET)
Intended effect of pumping EW-1

DATA FROM JUNE 2018

Plume seems to be starting to bifurcate

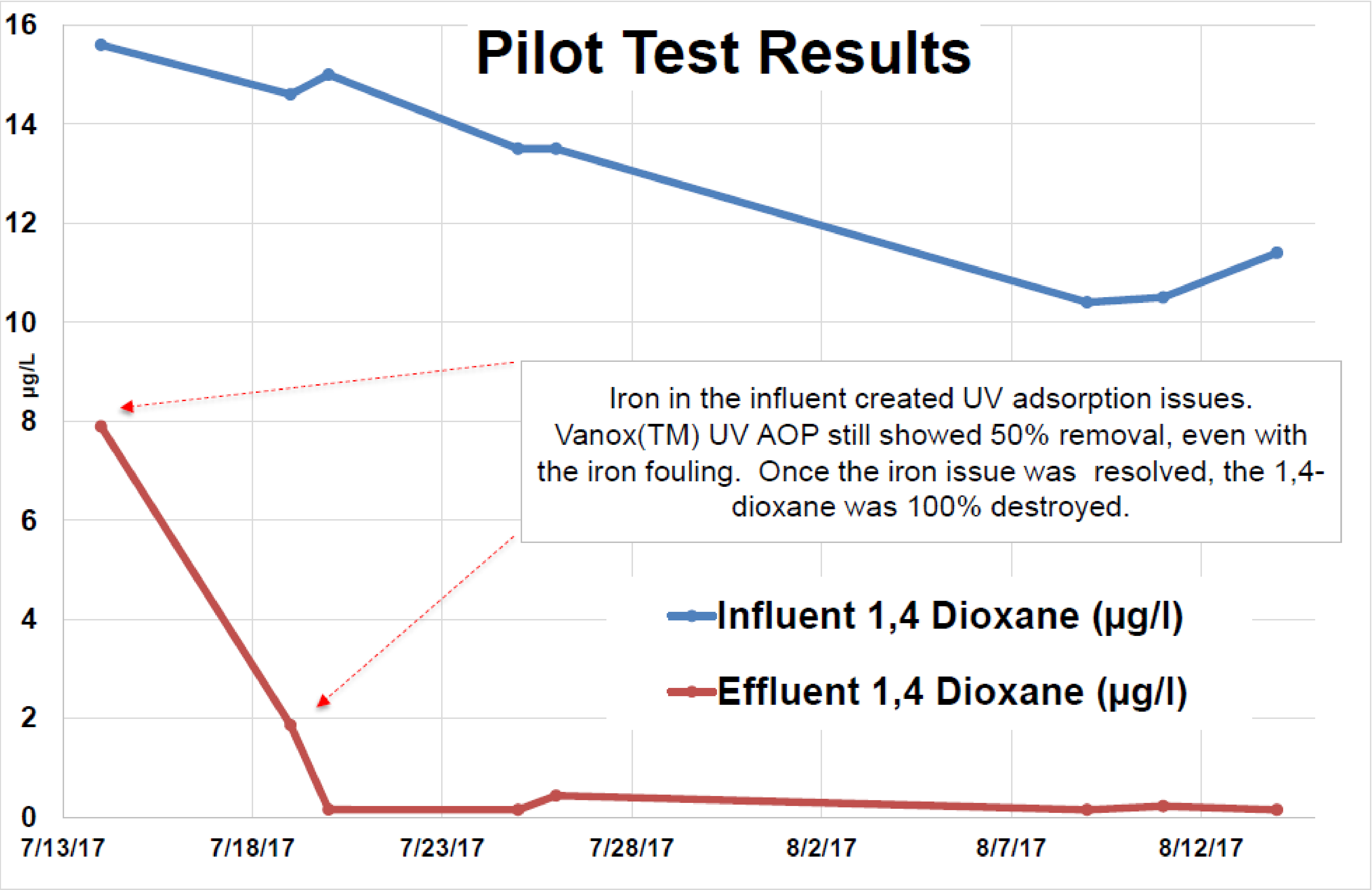


What happens to the groundwater when it gets extracted (pumped) from the ground?

- Normally, there are a variety of methods available for treating toxic organic compounds in groundwater (GW)
- For example, for a long time at W.R. Grace they extracted GW contaminated by solvents and treated it above ground by:
  - "stripping" the solvent compounds out of the GW into air
  - then using a carbon filter to "pull" the solvents out of the air
  - This is a very common way to treat volatile organic compounds in GW
- Another common approach is to pass water directly through a liquid-phase carbon filter bed
- Then the treated water is discharged… somewhere

How are they treating the groundwater pumped from EW-1?

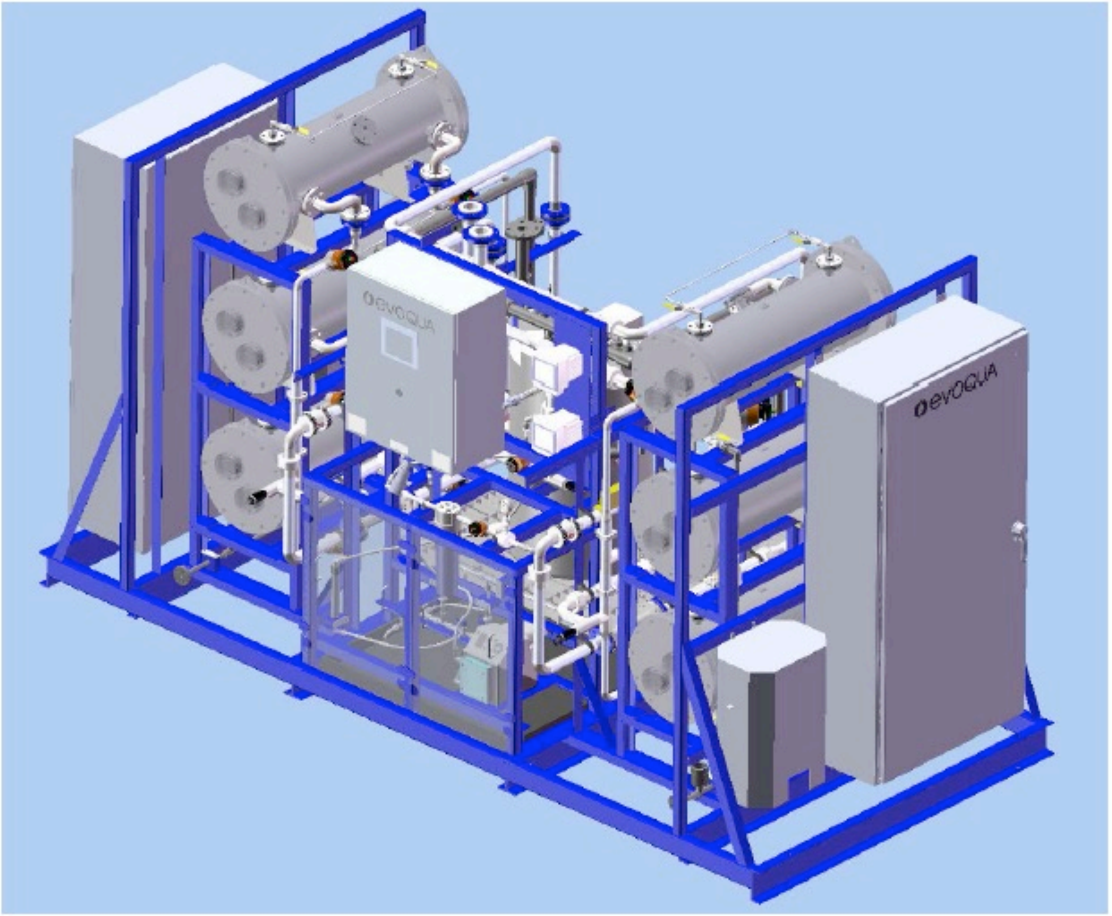
- The “normal” methods don’t work well for 1,4-dioxane: it’s chemistry makes it want to be in water much more than air or on carbon
- While searching for the best approach, water has been treated by liquid-phase carbon filtration, and discharged to the Assabet River
  - Carbon is removing ~ 45% of the dioxane (average discharge less then 10 µg/l)
- “Final” method pilot tested and selected for the NMI plume water is a destructive method called “UV advanced oxidation”


Pilot Test Results
16
14
12
10
8
6
4
2
0
µg/L
7/13/17
7/18/17
7/23/17
7/28/17
8/2/17
8/7/17
8/12/17
Iron in the influent created UV adsorption issues. Vanox(TM) UV AOP still showed 50% removal, even with the iron fouling. Once the iron issue was resolved, the 1,4-dioxane was 100% destroyed.
Influent 1,4 Dioxane (µg/l)
Effluent 1,4 Dioxane (µg/l)

UV Advanced Oxidation Process (AOP)

- EPA intention is for system to remove 95% of dioxane in influent
- UV-AOP adds a chemical oxidant (persulfate) to the extracted water and then ultraviolet light to destroy the dioxane
- Products are sulfate, CO_2 and water
- Pilot testing achieved removal to "non-detect" (< 0.15 µg/l)
- System will have 6 reactors to allow for increased flow in the future

Evoqua Vanox™ UV AOP - Six-Reactor System



When does it all stop? What about the Source?

- EPA is requiring groundwater cleanup to 0.46 µg/l 1,4-dioxane
- Source area appears to be the bedrock below NMI site
- 1,4-dioxane is migrating very slowly from bedrock to overburden
- Future will either be:
  - Install extraction well(s) in bedrock source area and try to remove all of the dioxane → will take a VERY long time
  - Inject reactant (e.g., persulfate chemical oxidant) into injection wells to destroy dioxane *in-situ* → no proven track record for dioxane in bedrock
- There have been recent advances in bioremediation of dioxane in preliminary tests, but not at low concentrations in bedrock.
- Time and more research may provide answers!!